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(54) PROCEDE PERMETTANT DE SEPARER PAR FILTRATION TRANSVERSALE UN MELANGE EN UNE FRACTION SOLIDE ET UNE FRACTION LIQUIDE

(54) METHOD AND DEVICE FOR SEPARATING A MIXTURE INTO SOLID AND LIQUID PARTS BY CROSS-FLOW FILTRATION

(57)
The invention relates to a method according to which a pumpable mixture of vegetable or animal cell units, notably of whole fruit, is prepared by crushing and digestion to yield a mash. Said mash is fed to a filtration installation having at least one flow path (pass) (9, 9', 10, 10', 11, 11', 12, 12') for the flow and an outlet (30) for separated liquid parts (permeate). The mixture to be separated is circulated several times under pressure in the flow paths of a cycle system, the liquid parts being separated as juice. No use is made of known juice extractors and the mash is filtered directly.

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(54) **PROCEDE PERMETTANT DE SEPARER PAR FILTRATION TRANSVERSALE UN MELANGE EN UNE FRACTION SOLIDE ET UNE FRACTION LIQUIDE**

(54) **METHOD AND DEVICE FOR SEPARATING A MIXTURE INTO SOLID AND LIQUID PARTS BY CROSS-FLOW FILTRATION**

(57) L'invention concerne un mélange en purée préparé par broyage à partir d'ensembles de cellules végétales ou animales, notamment à partir de fruits entiers, et par désintégration sous forme de magma. Ce magma est cédé à une installation de filtration comprenant au moins une section d'écoulement (Passe) (9, 9', 10, 10', 11, 11', 12, 12') destinée au flux et une sortie (30) destinée aux fractions liquides séparées (perméat). A cette occasion, le mélange à séparer est recyclé plusieurs fois sous pression par les sections d'écoulement en formant ainsi un circuit, les fractions liquides étant séparées sous forme de jus. On renonce à la technique connue de pressage du jus et le magma est directement filtré.

(57) The invention relates to a method according to which a pumpable mixture of vegetable or animal cell units, notably of whole fruit, is prepared by crushing and digestion to yield a mash. Said mash is fed to a filtration installation having at least one flow path (pass) (9, 9', 10, 10', 11, 11', 12, 12') for the flow and an outlet (30) for separated liquid parts (permeate). The mixture to be separated is circulated several times under pressure in the flow paths of a cycle system, the liquid parts being separated as juice. No use is made of known juice extractors and the mash is filtered directly.

ABSTRACT

In this process, a pumpable mixture of cell compounds of plant or animal origin, in particular from whole fruits, is prepared in the form of mash by comminution and disintegration. This mash is delivered to a filtration system having at least one flow route (pass) (9, 9', 10, 10', 11, 11', 12, 12') for the flow and one outlet (30) for liquid components (permeate) extracted. The mixture to be separated is recirculated under pressure multiple times through the flow routes in a circulation loop, and the liquid components are extracted in the form of juice. Known juice presses are dispensed with, and the mash is filtered directly.

(Fig. 1)

PROCESS FOR SEPARATING A MIXTURE INTO SOLID AND LIQUID COMPONENTS BY CROSSFLOW FILTRATION

The invention relates to a process for separating a pumpable mixture of cell compounds of plant or animal origin into solid and liquid components by crossflow filtration, and to an apparatus for performing the process.

One process for producing juices from fruits is known from U.S. Patent 4,716,044 (Thomas et al). In it, from the fruits, a pumpable liquid puree made up of fruits and juice is created. This puree is pumped at a pressure between 7 bar and 70 bar in a single pass through a rigid, porous, tubular housing with a diameter between 1.6 cm and 15 cm. An ultrafiltration membrane suitable for foods and having a certain initial permeability is attached to the inside faces of the housing. The outlet pressure at the housing is kept between 3 bar and 7 bar.

In contrast to conventionally obtaining fruit juice using juice presses, the process of U.S. Patent 4,716,044 is called direct juice extraction. Because of the single pass performed there, a large number of ultrafiltration modules connected in series, as well as a high filtration pressure in the range of 40 bar to 60 bar, are required. Given the membrane tube diameters employed, this dictates the use of metal membranes. If at the same time a plurality of flow routes (passes) are employed parallel with a single pass, then increasingly the problem arises of the blockage of individual flow routes (passes), because of clogging of the ultrafiltration modules. An apparatus functioning by this process is known as an ultrapress. However, because of the above disadvantages and its lack of economy, it has so far failed to become established in the industry.

The object of the invention is to overcome these disadvantages of the known process by means of a novel separation process, and to disclose an apparatus for performing it.

According to the invention, this object is attained, in a process of the type defined at the outset, in that a mash is prepared from cell compounds of plant or animal origin, and in particular from whole fruits, by comminution and disintegration; that a filtration system with at least one flow route (pass) for the flow of the mixture to be separated and

with an outlet for liquid components (permeate) extracted is furnished; and that at least some of the prepared mash is recirculated multiple times through the flow routes under pressure in a circulation loop, in the form of a pumpable mixture to be separated, in the course of which the liquid components are extracted in the form of juice.

The process is preferably performed in such a way that at the outlet of each flow route (pass), the flow rate and/or pressure of the mixture to be separated is detected and regulated in such a way that the pressure and the flow rate are controlled to set-point values, the pressure by means of a variable throttle at the outlet and the flow rate by means of at least one circulation pump in the circulation loop; and that if these set-point values are not attained in the process, the outflow of the liquid components (permeate) extracted is also reduced or interrupted.

An apparatus according to the invention for separating a pumpable mixture of cell compounds of plant or animal origin, in particular a mash prepared from whole fruits by comminution and disintegration, into solid and liquid components by crossflow filtration includes at least two filtration modules, which are connected in series in a retentate circulation loop for the mixture to be separated, and the filtration modules include individual tubular membranes with an inside diameter of more than 10 mm.

Further variants of the process and the apparatus for performing it are defined by the claims. Along with attaining the stated object, the invention also offers the following advantages:

- a high flow capacity (flux) through the filtration membranes used, which amounts to 2.4 times the capacity of comparable known systems;

- a high juice yield, even without diafiltration, of up to 80 weight percent of the mixture if suitable filtration modules (Super-Cor modules) are used;

- high operational reliability,

- substantially more-economical operation of direct filtration systems;

- substantially lower capital costs;

- known juice presses are dispensed with, and the mash is filtered directly.

Exemplary embodiments of the invention are described in further detail in the ensuing description and in the drawing figures. Shown are:

Fig. 1, a diagram of a direct filtration system for performing the process according to the invention for separating a mixture;

Fig. 2, a variant of the direct filtration system of Fig. 1;

Fig. 3, a diagram of closed control loops for a direct filtration system of Fig. 1;

Fig. 4, a diagram of a partial retentate discharge from the product circulation loop of a system of Fig. 1;

Fig. 5, a diagram of a partial or total retentate discharge from the product circulation loop of a system of Fig. 1;

Fig. 6, a diagram of a direct filtration system for performing the process according to the invention for separating a mixture, with a compact design, for minimizing product residues in positive product displacement; and

Fig. 7, a variant of the direct filtration system of Fig. 1.

The direct filtration system schematically shown in Fig. 1 is suitable in particular for separating a fruit mash into a raw juice and a residue (marc). A mill, not shown and known per se, is used for comminuting and disintegrating whole fruits, thereby preparing a pumpable mash. This mash travels through a line 1 with a shutoff valve 2 into a batch tank 3, which is provided in a manner known per se with an agitator device 4. Connected to the batch tank 3 is a product circulation loop with a crossflow filtration system, whose design will be described below.

Connected directly to the bottom of the batch tank 3, as shown in Fig. 1, is a recirculating pump 5 for the contents of the batch tank 3, which are in the form of a pumpable mixture to separated. Via a connecting line 6, a mixer 7, and a symmetrical distributor 8, the recirculating pump 5 pumps this mixture into four parallel flow routes (passes), each of which includes two crossflow filtration modules 9, 9', 10, 10', 11, 11', 12, 12'. One regulating valve 13, 14, 15, 16 for regulating the pressure and flow rate of the mixture is provided at the outlets of each of the four passes. Each regulating valve 13, 14, 15, 16 is supplied with the output signal of a sensor 13', 14', 15', 16', upstream of it, for the flow rate and/or pressure of the mixture.

The outlets of the regulating valves 13, 14, 15, 16 are connected via a second symmetrical distributor 17 to a return line 18. The return line 18 returns a portion (retentate) of the mixture into the batch tank 3, via a reverse-action pump 19 for adjusting the mixture pressure and via a shutoff valve 20, after a liquid component has been extracted in the filtration modules 9, 9', 10, 10', 11, 11', 12, 12'. A line 22 for discharging retentate from the circulation loop is also disposed at the outlet of the pump 19, via a shutoff valve 21.

As Fig. 1 shows, a flow rate sensor 23 is provided between the recirculating pump 5 and the mixer 7; a pressure sensor 24 is provided between the mixer 7 and the distributor 8; and a further pressure sensor 25 is provided at the outlet of the second symmetrical distributor 17. The output signals of the sensors 23, 24 and 25 are delivered to the recirculating pump 5 and to the reverse-action pump 19 for controlling the flow rate and pressure of the mixture in the product circulation loop. Between the mixer 7 and the distributor 8, there is a vessel 26 with a shutoff valve 27 for compensating for pressure surges originating in the recirculating pump 5. Along with the line 1 for delivering the mash, a line 28 with a shutoff valve 29 is also provided, for delivering water to the batch tank 3 in the event that the residue from the mash (retentate), after the end of the juice extraction from the filtration system is to be positively displaced or diafiltered. The extracted juice is discharged as permeate from the filtration modules 9, 9', 10, 10', 11, 11', 12, 12' by means of lines 30.

The mode of operation of the filtration system described thus far will readily be apparent to one skilled in the art. Once the batch tank 3 has been filled via the line 1 up to a suitable level with the mash to be separated, this level is kept constant by further replenishment, and the product is filtered by recirculation until such time as the product quantity to be processed has been supplied, and the residue (retentate) from the inspissation must still remain pumpable. To avoid undesired or impermissible operating states, different variants of the separating process are employed.

For instance, if the set-point value for the pressure of the product in the filtration modules 9, 9', 10, 10', 11, 11', 12, 12' fails to be attained because the viscosity is too low, then the pressure drop of the retentate at the regulating valves 13, 14, 15, 16 can be increased, or the juice outflow through the lines 30 can intermittently be interrupted. On the other hand, if with increasing inspissation of the product a risk of blockage or an impermissibly high pressure occurs in the circulation loop as a consequence of the high flow resistance, then for a limited period of time, the juice (permeate) extracted in the filtration modules can be returned to the mixture at overpressure through the membranes.

To improve the pumpability and reduce the viscosity of the mixture, a gas or a gaslike substance can also be admixed with the mixture at some suitable point in the circulation loop. If the viscosity and thus the pressure drop in the residue (retentate) reach a maximum allowable value, or if the yield of juice reaches a predetermined value, then to further increase the yield, diafiltration involving mixing an eluting agent into the mixture to be separated can prove advantageous. This diafiltration is ended if the soluble components in the juice drop below a predetermined value, or if a desired total yield is attained.

The viscosity of the mash can also be reduced by enzymatic treatment with pectinases or cellulases. An original reduction in the viscosity of the mash is also attained by heating to more than 30°C or 60°C. The quality of the juice as ascertained by sensor can be improved by extracting volatile flavoring substances from the mash before the solid/liquid separation and then adding the flavorings back to the extracted juice again later. With a view to the quality as ascertained by sensors, if necessary

seeds, stems and peels, as part of the prepared mash, are also extracted before the recirculating filtration.

Fig. 2 schematically shows a variant of the direct filtration system of the type described in conjunction with Fig. 1; reference numerals from Fig. 1 refer to corresponding structural elements in Fig. 2. In the system of Fig. 2, instead of only one reverse-action pump 19 (Fig. 1) for adjusting the mixture pressure, a separate reverse-action pump 19', 19'', 19''', 19'''' is provided for each of the four flow routes. Two sensors are disposed upstream of each of these pumps, namely four flow rate sensors 33, 34, 35, 36 and four pressure sensors 33', 34', 35', 36'. As the arrows in the signal lines of the sensors in Fig. 2 represent, the reverse-action pumps 19'-19'''' and the recirculating pump 5 are triggered by the output signals of the sensors 24, 33-36, and 33'-36'; conversely, only the recirculating pump 5 is triggered by the output signals of the sensor 23.

As in the system of Fig. 1, in that of Fig. 2 the pressure and flow rate controls for the individual flow routes (passes) again serve to prevent blockages in the product during the filtration and in the ensuing rinsing out of the filtration modules 9-12, 9'-12'. In a variant, not shown, of the system of Fig. 2, the filtration modules 9-12, 9'-12' can be connected in series for a terminal expulsion of the largely sapped residue (retentate). By means of this provision, blockage of individual parallel filtration modules can be avoided, but this provision is usable only if the then-required expulsion pressure does not exceed the allowable operating pressure of the filtration modules.

In Fig. 1 and Fig. 2, the closed control loops for regulating the pressure and flow rate of the pumpable mixture to be separated are shown only symbolically by the signal lines of the sensors. Fig. 3 now shows a diagram of closed control loops for a direct filtration system of Fig. 1 in detail. Here only one filtration module 9'' is provided, which has one inlet 38 for the mixture, and one outlet 37 for the residue and one outlet 42 for the extracted permeate. To detect the pressure and the flow rate, a pressure sensor 24 and a flow rate sensor 23 are disposed at the inlet 38; a pressure sensor 25 and a flow rate sensor 13'' are disposed at the outlet 37; and a pressure sensor 30' is

disposed at the outlet 42 for the permeate. As the signal lines of these sensors in Fig. 3 show, their output signals are all delivered to a regulator and control unit 40.

A regulating valve 41 is incorporated into the return line 18 at the outlet 37 for the residue, and a regulating valve 43 is incorporated into the line 30 for discharging the permeate from the outlet 42. As Fig. 3 shows, the regulating valves 41, 43 are adjusted by the regulator and control unit 40 via control lines. These adjustments are done in such a way that the set-point values for the pressure and flow rate are attained. If this should prove to be impossible because of a blockage in the filtration module 9'', then first the regulating valve 43 is closed. Next, as a further provision, pressurized water is fed to the filtration membranes on the permeate side, via a control valve 44 disposed at the outlet 42 for the extracted permeate, and thus a reverse rinsing is initiated in a manner known per se.

If the pressure or flow rate at the outlet 37 for the residue of Fig. 3 is too low, or if they are too unequal for individual passes, then the following provisions are performed in succession, until a remedy is achieved:

- open the regulating valve 41, or pump off more retentate at the outlet 37;

- increase the flow rate at the inlet 38 (as measured with the sensor 23) by increasing the rpm of the feed pump 5;

- close regulating valve 43 for the permeate;

- supply water via control valve 44.

As already described in conjunction with Fig. 1, this direct filtration system is intended for a separation process in which a batch of product, placed in the batch tank 3, is sapped by recirculation; the shutoff valve 21 remains closed and is not opened until there is a need to expel the largely sapped residue (retentate). Depending on the quantity of juice extracted from the circulation loop, fresh mixture is introduced constantly into the batch tank via the line 1 during the process of sapping.

In contrast to this batch mode of operation, a continuous operating mode of the direct filtration system employs a continuous partial retentate discharge from the product circulation loop. A diagram of a variant, intended for this purpose, of the system of Fig. 1 is shown in Fig. 4. A circulation loop for recirculating the mixture to be separated is schematically shown in Fig. 4; it includes a filtration module 9'', as well as a recirculation pump 5 at its inlet and a reverse-action pressure-holding pump 19 at its outlet. In the recirculation directly to the pump as in Fig. 4, the batch tank 3 of Fig. 1 is omitted.

The product circulation loop is closed by a return line 18' from the outlet of the pressure-holding pump 19 to the inlet of the recirculating pump 5. For partial retentate discharge from the product circulation loop, a likewise reverse-action discharge pump 21' is disposed at the outlet of the pressure-holding pump 19. The retentate is discharged via a line 22, and fresh product is correspondingly supplied continuously via a line 1'. No further details of the direct filtration system of Fig. 1 are shown again in the schematic view in Fig. 4.

Fig. 5 shows a variant of the circulation loop of Fig. 4, in which the discharge pump 21' is connected between the pressure-holding pump 19 and the outlet of the filtration module 9''. This arrangement makes it possible to discharge the retentate either partially, as in Fig. 4, or totally, without recirculation in the circulation loop. For the latter case, the pump 19 is simply turned off. This case occurs especially in the batch mode of operation, when the retentate of a batch of product placed in the batch tank 3 is expelled from the system once a desired yield is attained.

Fig. 6, in a diagram, shows a variant of a direct filtration system of Fig. 1 for performing the process according to the invention for separating a mixture, with a compact design, for minimizing product residues in the event of positive product displacement. Here the reverse-action pressure-holding pump 19 communicates on the outlet side directly with the batch tank 3 and is spatially disposed directly on it. The length of the connecting lines between the feed pump 5 and the filtration module 9'' and also between the filtration module 9'' and the pressure-holding pump 19 is also kept as short as possible.

In a variant of the direct filtration system in Fig. 7, the recirculating pump 5 of Fig. 1 is replaced by one recirculating pump 5' for each of the four individual flow routes (passes). In this case, each pass includes three filtration modules 9''' connected in series. The product from the batch tank 3 travels via a single distributor line 50 and shutoff valves 51 to the four recirculating pumps 5'. The residues (retentates) from the four flow routes (passes) travel back into the batch tank 3, via a single collection line 52 and shutoff valves 53, a return line 18, a pressure- holding pump 19, and a shutoff valve 20.

Between each of the recirculating pumps 5' and the first filtration modules 9''' of the four passes, there is one flow rate sensor 23, and there is also one flow rate sensor 23' at each of the outlets of the four last filtration modules 9'''. The output signals of the flow rate sensors 23 act, as shown in Fig. 7, on the pressure-holding pump 19, while the output signals of the flow rate sensors 23' act on the four recirculating pumps 5', in order to regulate the flow rates through the four passes to their set-point values. The permeates extracted in the filtration modules 9''' travel into an outlet line 55 for the extracted fruit juice, via collection lines 30'' and throttles 54.

The invention is not limited to the described exemplary embodiments of the process and the apparatuses for performing it. Combinations with provisions known per se, in the manner indicated below, do not depart from the scope of the invention:

In the preparation of the mixture to be separated, peels, seeds and stems can advantageously be removed from the mash.

When a filtration system with a plurality of separation stages in series is employed, economical low-pressure filtration modules can be used in the first stage, if the transmembrane pressure there is limited to a maximum of 8 bar or 10 bar. Such filtration modules include tubular membranes of organic material, whose support tubes are produced by winding of a tape.

If a plurality of filtration modules with tubular membranes in series are used, then in each filtration module, the inside diameter and tube length of the tubular membranes are

adapted to a different product viscosity, and those filtration modules in the circulation loop whose dimensioning is poorly adapted to the product viscosity at that specific time can be turned off by bypassing them.

Suitable filtration modules include commercially available apparatuses known by the trademark Supercore made by Koch or the trademark Super-Cor or A 19 made by PCI.

As feed pumps for products of relatively high viscosity, eccentric worm pumps are suitable.

In the event of positive displacement of an already sapped residue (retentate) from the separation system by means of water, abrupt changes in viscosity, which can lead to a blockage of parallel tubular membranes, can be averted in a retentate line by means of longitudinal mixers.

With regard to the separation range of the filters, the primary application is in microfiltration (MF) and ultrafiltration (UF) for clear juices. With macrofiltration, it is also possible to produce cloudy juices, of the kind known from conventional presses. For the Japanese market, Vitamin C is added for oxidation reduction of the mash.

CLAIMS

1. A process for separating a pumpable mixture of cell compounds of plant or animal origin into solid and liquid components by crossflow filtration, characterized in that a mash is prepared from cell compounds of plant or animal origin, and in particular from whole fruits, by comminution and disintegration; that a filtration system with at least one flow route (pass) (9, 9', 10, 10', 11, 11', 12, 12') for the flow of the mixture to be separated and with an outlet (30) for liquid components (permeate) extracted is furnished; and that at least some of the prepared mash is recirculated multiple times through the flow routes under pressure in a circulation loop, in the form of a pumpable mixture to be separated, in the course of which the liquid components are extracted in the form of juice.

2. The process of claim 1, characterized in that at the outlet of each flow route (pass) (9, 9', 10, 10', 11, 11', 12, 12'), the flow rate and/or pressure of the mixture to be separated is detected and regulated in such a way that the pressure and the flow rate are controlled to set-point values, the pressure by means of a variable throttle (13, 14, 15, 16) at the outlet and the flow rate by means of at least one circulation pump (5, 5') in the circulation loop; and that if these set-point values are not attained in the process, the outflow of the liquid components (permeate) extracted is also reduced or interrupted.

3. The process of claim 1, characterized in that at the entrance to each flow route (pass) (9, 9', 10, 10', 11, 11', 12, 12'), the pressure of the mixture to be separated is detected and is regulated, via a variable throttle (13, 14, 15, 16) at the outlet, to a set-point value; and that if the permissible values of the flow rate and/or pressure at the outlet cannot be adhered to, then the flow rate at the entrance to the flow routes (passes) is reduced.

4. The process of claim 1, characterized in that if a risk of blockage of the flow routes (passes) (9, 9', 10, 10', 11, 11', 12, 12') is detected for the mixture to be separated, because of an excessive flow resistance, the liquid components (permeate)

extracted are recirculated into the mixture at overpressure through the membranes of the crossflow filtration for a limited period of time.

5. The process of claim 1, characterized in that the flow rate of the mixture to be separated (retentate flow rate) is adjusted via closed control loops as a function of its viscosity (retentate viscosity).

6. The process of one of claims 1-5, characterized in that to improve the pumpability and reduce the viscosity of the mixture to be separated, a gas or gaslike substance is admixed with the mixture.

7. The process of one of claims 1-6, characterized in that after the completion of the filtration, the mixture (retentate) circulating in the filtration system in the circulation loop is partly diluted with a low-viscosity liquid and expelled from the system.

8. The process of claim 1, characterized in that simultaneously with the recirculating crossflow filtration of the pumpable mixture to be separated, or directly following it, a recirculating diafiltration of the mixture is performed.

9. The process of claim 8, characterized in that the diafiltration is ended when the total yield of juice attains a predetermined value.

10. The process of claim 8, characterized in that the diafiltration is ended when the proportion of soluble substances in the juice in the separation process drops below a predetermined value.

11. The process of one of claims 1-10, characterized in that in the preparation of the mixture from a fruit mash of ground fruits, peels, seeds and stems are largely extracted from the mash.

12. The process of claim 1, characterized in that the viscosity of the mixture or the mash is reduced by mixing in a liquid.

13. The process of claim 1, characterized in that the viscosity of the mash is reduced by enzymatic treatment.

14. The process of claim 1, characterized in that the solids of the mash are pretreated with enzymes (cellulases).

15. The process of claim 1, characterized in that the mash is heated to a temperature of more than 30°C.

16. The process of claim 1, characterized in that before the solid/liquid separation, volatile flavoring substances are extracted from the mash.

17. The process of claim 1, characterized in that the mash is heated to a temperature of more than 60°C.

18. The process of claim 1, characterized in that a filtration system with at least two stages in series is furnished, and that in the first stage, the pressure of the mixture to be separated is kept to a maximum of 8 bar relative to the pressure of the separated-off liquid components (transmembrane pressure).

19. The process of claim 18, characterized in that the mixture to be separated (retentate) from the first stage is inspissated in a subsequent stage to a certain compactness (piercing firmness).

20. An apparatus for separating a pumpable mixture of cell compounds of plant or animal origin, in particular a mash prepared from whole fruits by comminution and disintegration, into solid and liquid components by crossflow filtration, characterized by at least two filtration modules (9, 9', 10, 10', 11, 11', 12, 12'), which are connected in series in a retentate circulation loop for the mixture to be separated, and the filtration modules include individual tubular membranes with an inside diameter of more than 10 mm.

21. The apparatus of claim 20, characterized in that at least two of the filtration modules (9, 9', 10, 10', 11, 11', 12, 12') succeeding one another in series in the retentate circulation loop include tubular membranes, which from one module to another differ in their internal diameter and/or in the filter tube length.

22. The apparatus of claim 20, characterized in that at least one filtration module includes more than three tubular membranes connected in series.

23. The apparatus of claim 20, characterized by at least two filtration modules (9, 9', 10, 10', 11, 11', 12, 12'), which are connected parallel in the retentate circulation loop and form separate flow routes (passes).

24. The apparatus of claim 20, characterized by filtration modules with an allowable operating pressure of less than 10 bar.

25. The apparatus of claim 20, characterized in that the filtration modules (9, 9', 10, 10', 11, 11', 12, 12') in terms of their model type are identical or similar modules known by the mark Supercore made by Koch or the mark Super- Cor or A19 made by PCI.

26. The apparatus of claim 23, characterized in that the filtration modules connected parallel in the retentate circulation loop are connected via symmetrical distributors (8, 17).

27. The apparatus of claim 20, characterized by at least one eccentric worm pump (5), which pumps the mixture to be separated in the retentate circulation loop.

28. The apparatus of claim 20, characterized by a batch tank (3), located in the retentate circulation loop, for the mixture to be separated and by at least one retentate pump (5) for pumping in the circulation loop, which is connected directly at the outlet of the batch tank or is disposed downstream of this outlet via a short pipe connection, compared to the length of the retentate circulation loop.

29. The apparatus of claim 20 or 28, characterized by at least one reverse-action pump (19) in the retentate circulation loop, which counteracts the retentate stream and serves to regulate the pressure of the retentate in the filtration modules.

30. The apparatus of claim 29, characterized by a branch line (22), disposed in the retentate circulation loop downstream of the reverse-action pump (19), which line has a further reverse-acting pump (21') and leads out of the retentate circulation loop.

31. The apparatus of claim 29, characterized in that the reverse-action pump (19) communicates on the outlet side directly with the batch tank (3) and is disposed in spatial terms directly on it.

32. The apparatus of claim 23, characterized by one pressure sensor (33'-36') and/or one flow rate meter (33-36) each, which are disposed at the outlet of each separate flow route (pass) (9, 9', 10, 10', 11, 11', 12, 12').

33. The apparatus of claim 23, characterized by structural elements (19'-19""), by which the flow quantities through the separate flow routes (passes) (9, 9', 10, 10', 11, 11', 12, 12') can be controlled individually.

34. The apparatus of one of claims 20-33, characterized by structural elements by which components succeeding one another longitudinally in the retentate circulation loop upstream of the filtration modules can be mixed with one another in the retentate stream, in particular in the event of dilution.

35. The apparatus of claim 32, characterized by one separate pump (5') each for controlling the pumping stream through each of the separate flow routes (passes) (9, 9', 10, 10', 11, 11', 12, 12').

36. The apparatus of claim 20, characterized in that the tubular membranes comprise organic material, and the support tubes are produced by winding of a tape.

FIG. 1

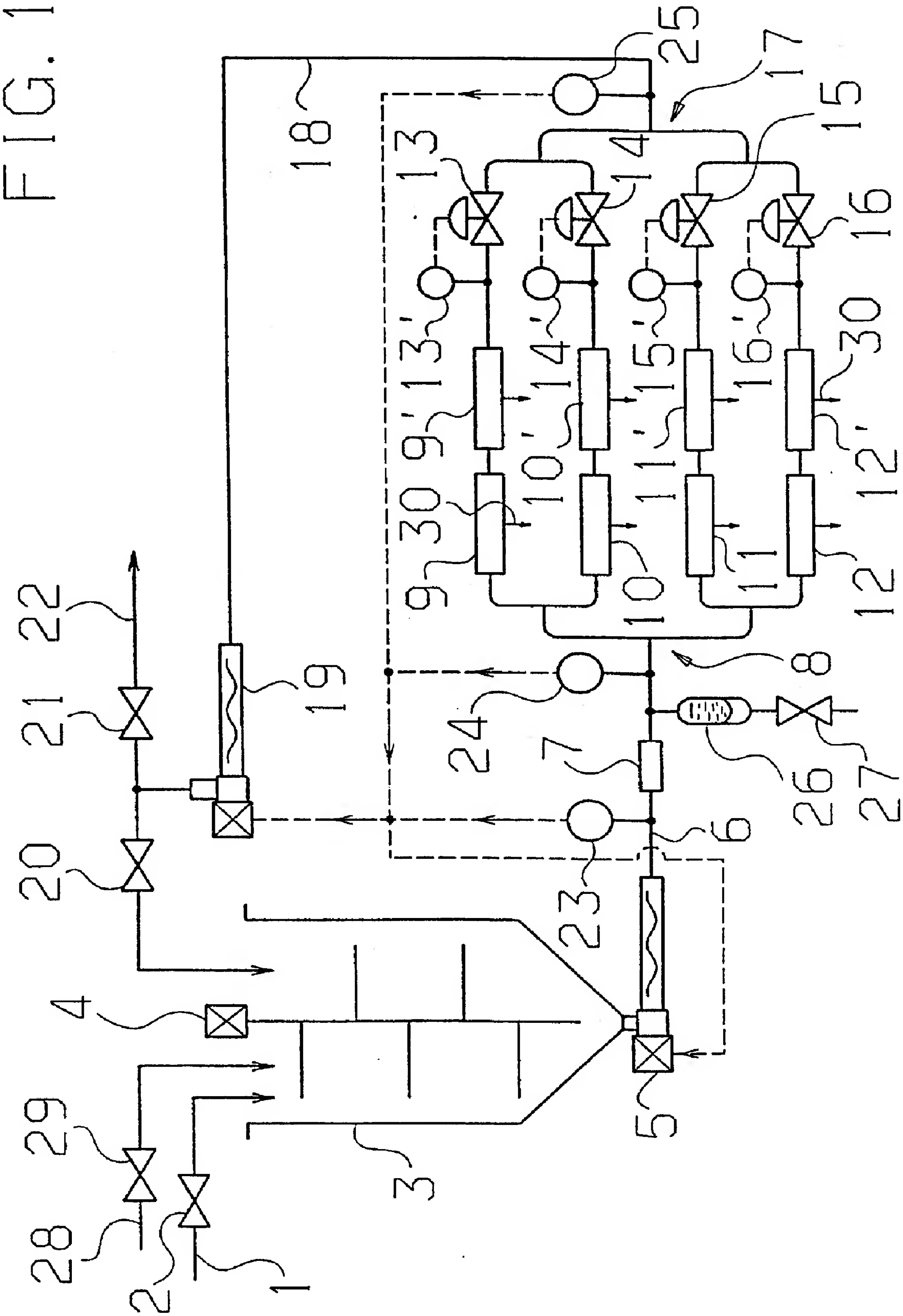
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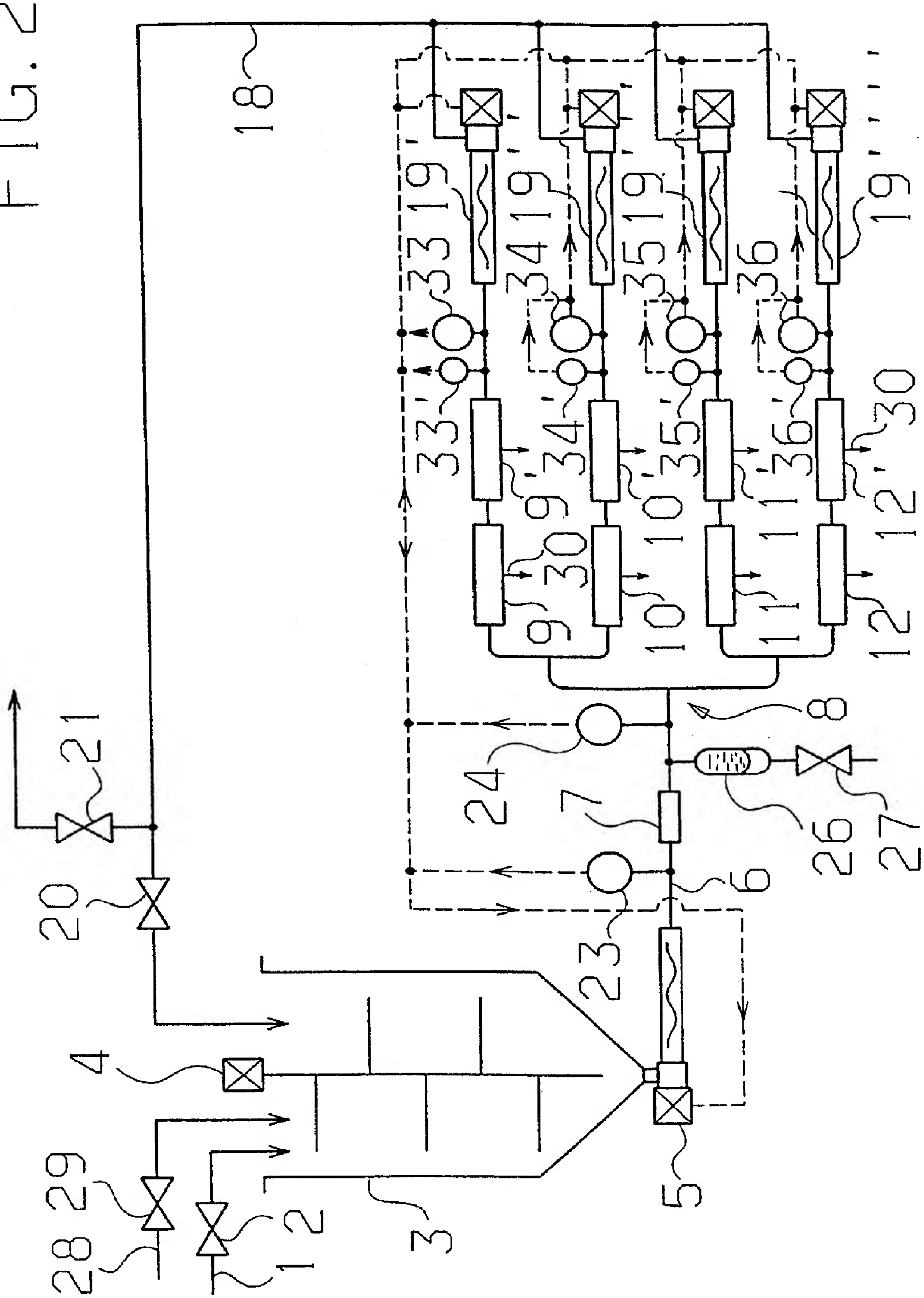
FIG. 2



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19
19'
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33'
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34'
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35'
36
36'

FIG. 3

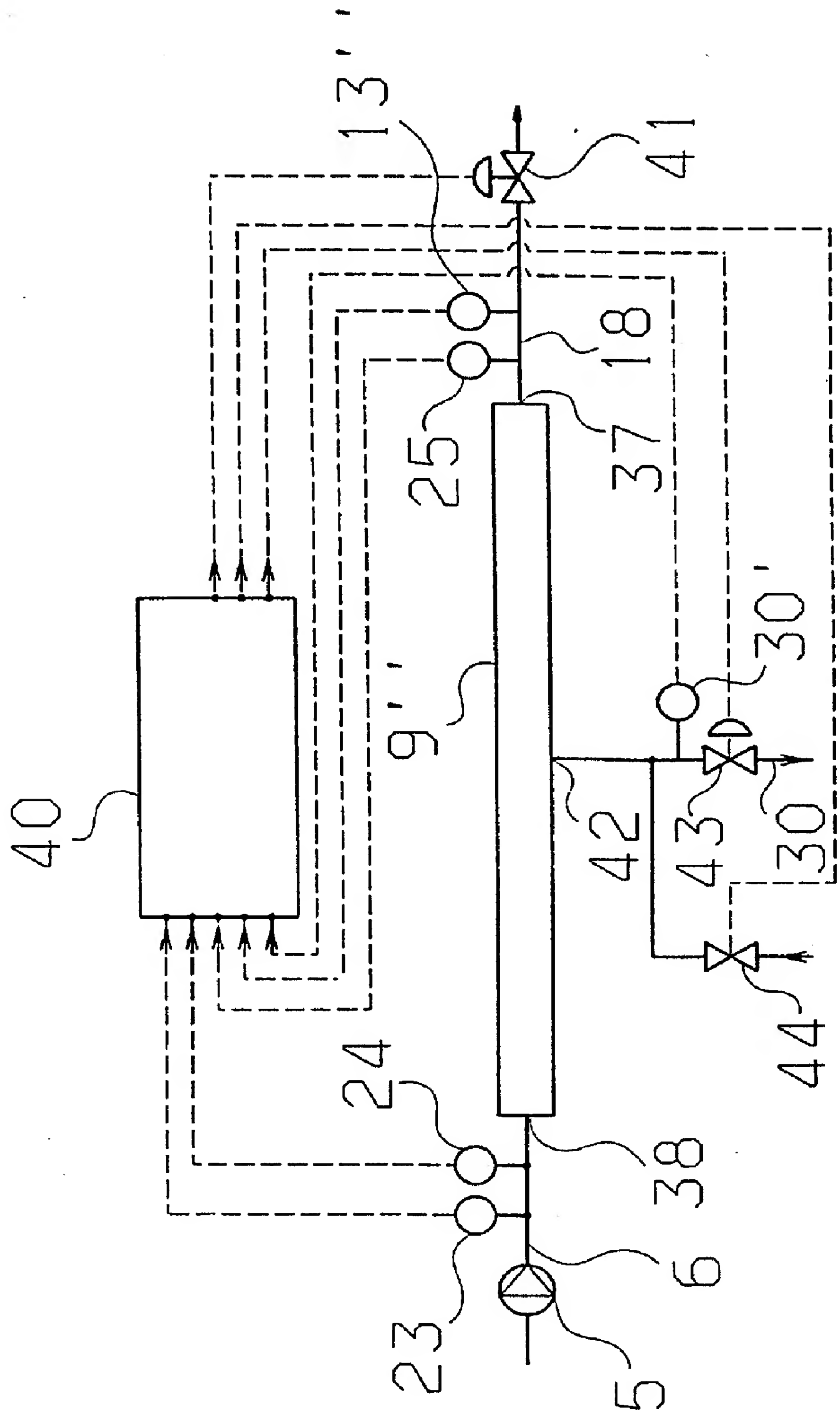

FIG. 4

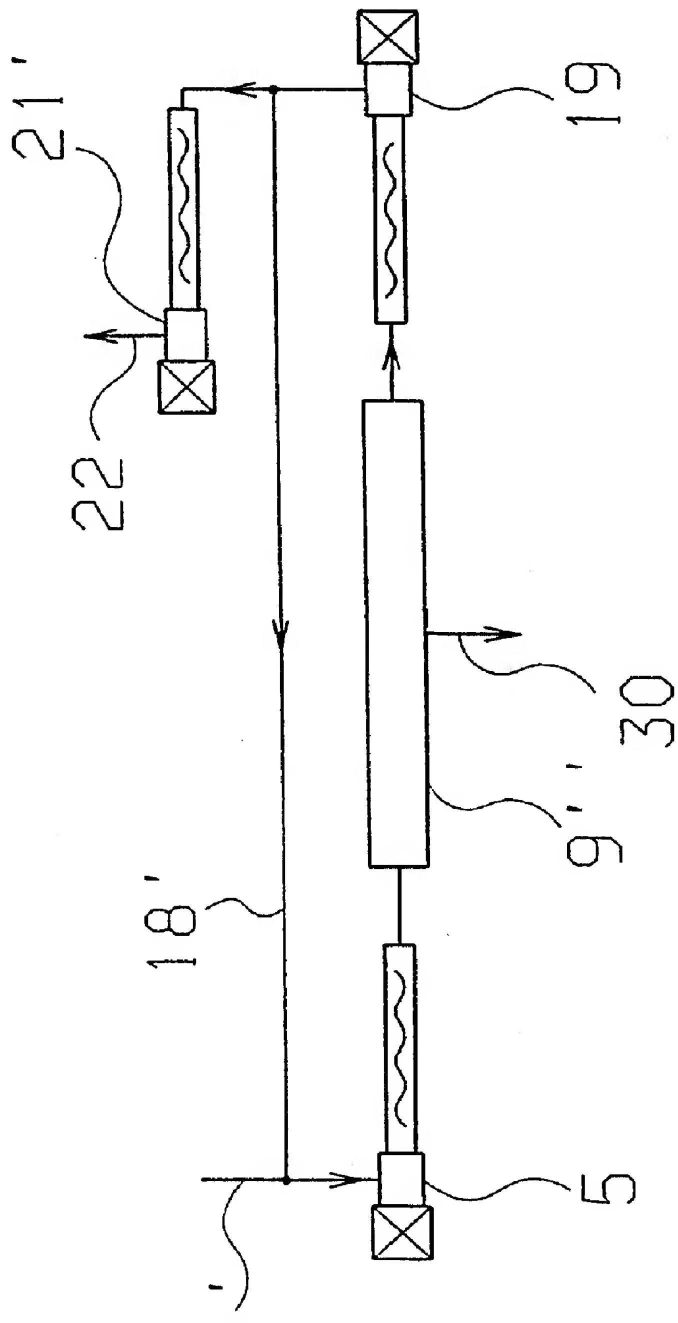

FIG. 5

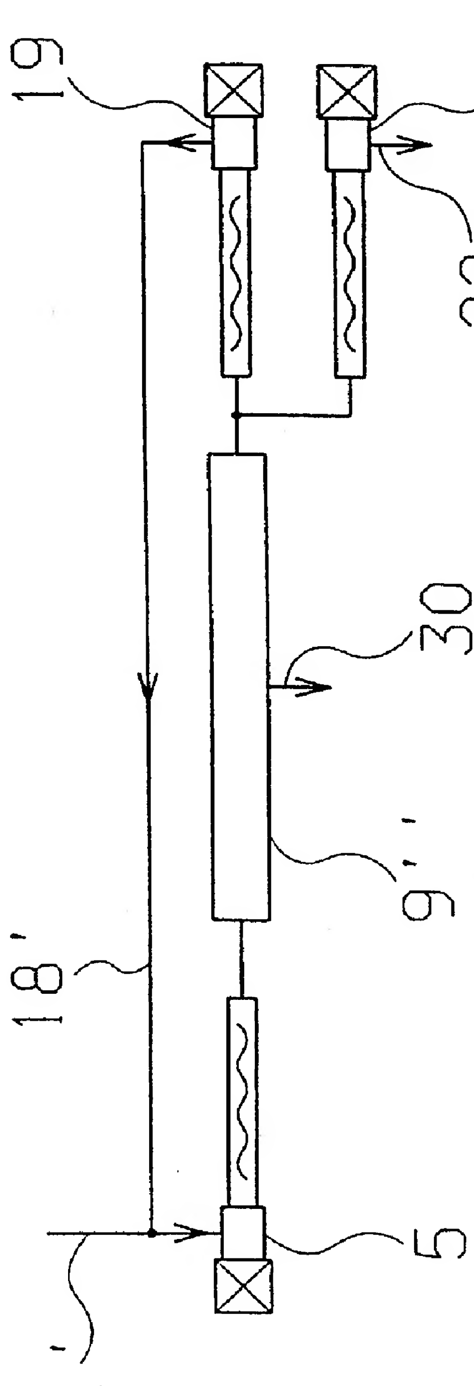

FIG. 6

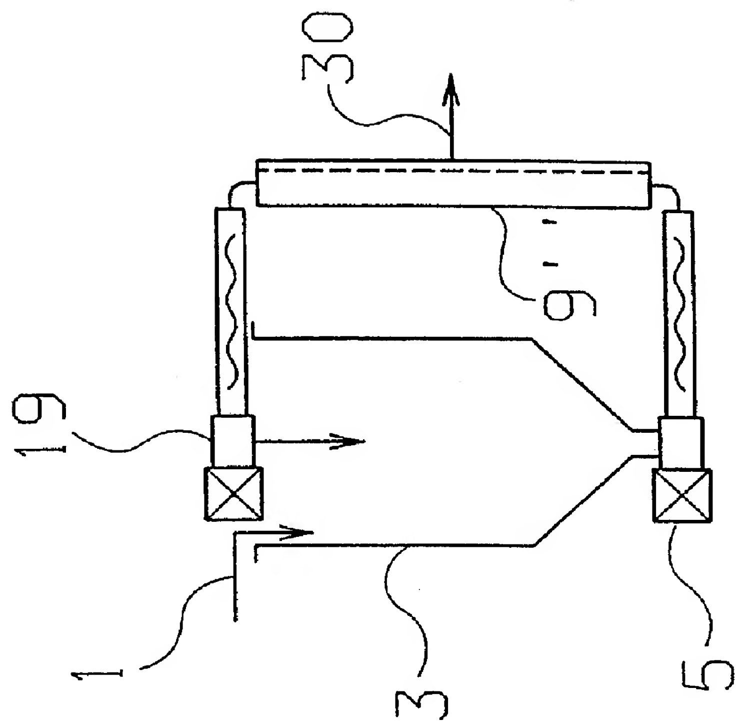

FIG. 7